

THE ROLE OF PERCHES IN ACCELERATING SEED ARRIVAL IN HUMAN-ABANDONED CLEARINGS WITHIN BHADRA TIGER RESERVE, INDIA

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Seed arrival is often the primary limitation to forest regeneration in denuded landscapes, with the number of seeds arriving diminishing rapidly with increase in distance from remnant seed sources. We compared seed rain collected at different distances from the forest edge in seed rain traps with and without introduced bamboo perches in human-abandoned agricultural clearings in Bhadra Tiger Reserve. The number of seeds collected per trap below perches was 38 times greater than the number of seeds collected in traps without perches. The species richness of seeds collected per trap below perches was ten-fold greater than in traps without perches. Our study showed that introducing artificial perches is an effective method to improve seed arrival into tree-less habitats, as has been found in studies elsewhere.

Keywords: Agricultural clearings, bird-perches, regeneration, seed rain

INTRODUCTION

Vegetation recovery in human-abandoned agricultural fields and pastures, especially in the initial stages, has been shown to be severely impeded by factors such as the unavailability of seeds, harsh micro-climatic conditions, degraded soil, competition with existing vegetation, and high rates of seed and seedling predation. Primary amongst these factors is the lack of seed arrival from adjoining forests (Aide and Cavelier 1994; Duncan and Chapman 1999; Holl 1999; Cubiña and Aide 2001). In tropical forests, more than 70-80% tree species are animal-dispersed and their dispersal is likely to be adversely affected by habitat modification as animals are less likely to traverse open habitats (Howe and Smallwood 1982).

Remnant trees in clearings foster regeneration by aiding arrival of bat- and bird-dispersed seeds by providing perch-sites as well as micro-habitats for regeneration of shade-loving species (Willson and Crome 1989; Duncan and Chapman 1999; Toh *et al.* 1999; Galindo-Gonzalez *et al.* 2000; Guevara *et al.* 2004). Restoring disturbed habitats by planting seedlings may often be expensive in terms of money and labour (McClanahan and Wolfe 1993). Alternate measures such as introducing artificial perches to simulate remnant trees in clearings have resulted in an increase in seed arrival and in some cases, a slight increase in seedling densities as well (McClanahan and Wolfe 1993; Aide and Cavelier 1994; Holl 1998; Shiels and Walker 2003).

We investigated whether introducing bamboo-perches improves arrival of bird-dispersed seeds in agricultural

clearings within Bhadra Tiger Reserve (Bhadra TR). These clearings were abandoned following a voluntary relocation programme in 2002. We investigated patterns in arrival of wind- and bird-dispersed seeds in seed traps below bamboo perches, and in control traps, at different distances from the forest edge, in 5 out of the 13 abandoned clearings in Bhadra TR.

METHODS

Study area

Bhadra TR (13° 22'-13° 47' N; 75° 29'-75° 47' S, area: 492 sq. km) is located within the Western Ghats biodiversity hotspot in India (Conservation International 2005, Fig. 1). Bhadra was notified as a Tiger Reserve in 1998, and the reserve is rich in faunal and floral diversity (Karanth 1982; Jathanna 2001). The Reserve is composed of moist deciduous forests in the southern portion, with dry deciduous forests towards the north (Meher-Homji 1990). The present study was carried out in the abandoned village sites of Madla, Vadihaddi, Hipla, Kesavé and Karvani. The clearings in the five abandoned villages aggregate to about 130 ha of riparian habitat.

Field methods

A 350 m long forest-field edge was selected in each of the five clearings. Along this edge, five points were marked at random and transects radiating into the clearing were established at each of these points for recording arrival of wind-dispersed seeds. Each transect consisted of seven traps radiating into the clearings at distances of 0, 2, 4, 8, 16, 32

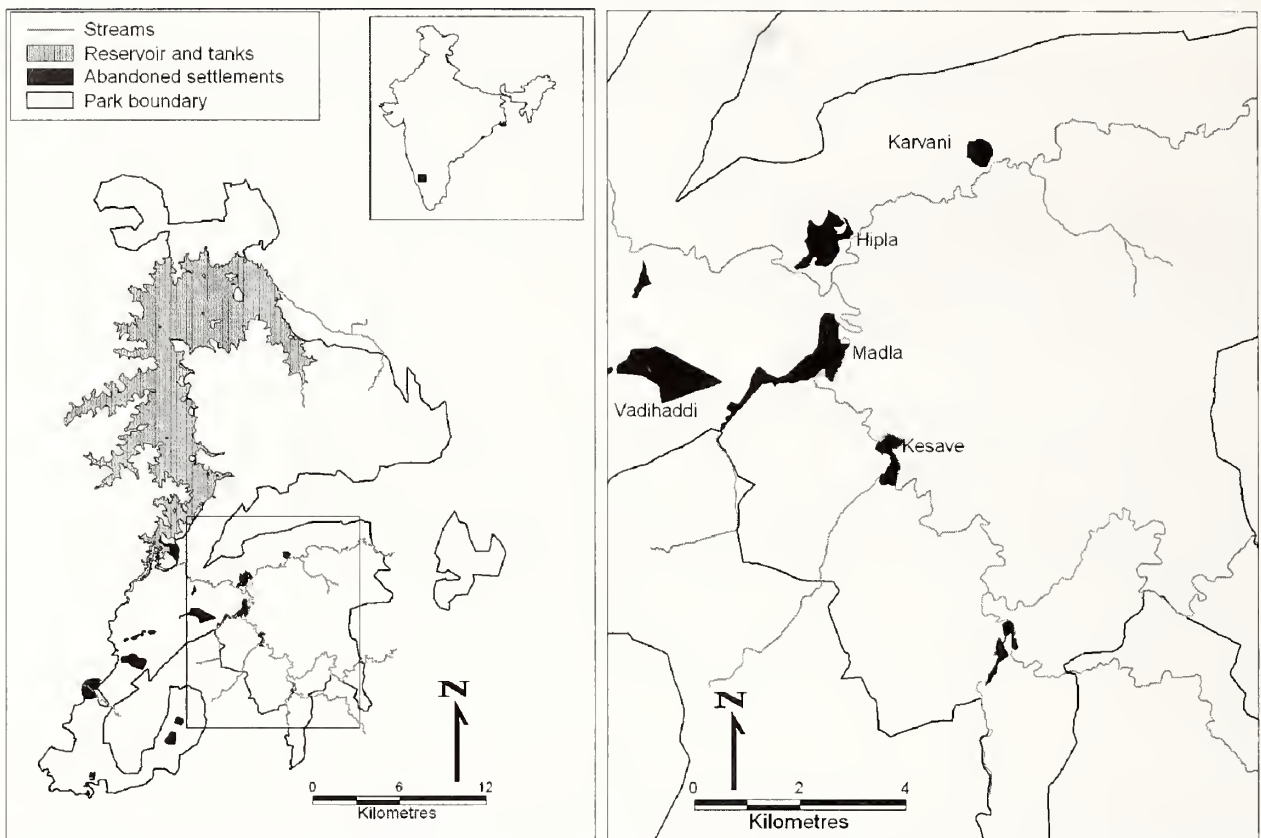


Fig. 1: On left: Map of Bhadra showing the Bhadra reservoir to the north-west, and the location of abandoned settlements (Inset map shows location of Bhadra within peninsular India). On right: (enlarged view of the area demarcated in the figure on left): Five of the 13 abandoned settlements in Bhadra that were chosen as replicate sites for this study

and 64 m from the forest edge. Seed traps consisted of pits, 0.1 m deep and 1 x 1 m wide, lined with cloth to enable detection of small seeds. Seed traps were visited fortnightly (five visits) between March 15 and May 31, 2006. During each visit, the pits were emptied and seeds of tree species counted and collected in numbered bags. Since most trees in Bhadra flower and fruit during the February-May dry season, the sampling period coincided with the main window of seed dispersal in this forest.

Bird perches were erected along one of the five transects established in each clearing, chosen at random (Fig. 2). Perches were bamboo poles (*Bambusa arundinacea*) about 7 m tall, and had at least ten lateral branches. Seed traps below the perches trapped both wind- and bird-dispersed seeds. Seed rain below the bird-perches was also collected fortnightly, with five collections between March 15 and May 31, 2006.

Analytical methods

Sites (i.e. village clearings) were considered as replicates and seed rain data from transects within each site were pooled for analysis, after compositing by distance. Seed rain density was log-transformed to achieve normal

distribution of errors, and to remove heteroscedasticity in the data. Few bird-dispersed seeds (about 0.1 seed / 5 fortnights/sq. m) were collected beneath perches in Hipla (a clearing with many remnant trees – more than 50 in the c. 1.6 ha sampled for seeds) and data from this clearing were not included in the analysis. The effects of perches and distance from edge on seed arrival were investigated using generalised linear models (GLMs [McCullagh and Nelder 1989]). Log-transformed seed rain was used as the response variable. The presence of perches (i.e., 'perch / no perch,' a categorical variable) and distance from the forest-field edge (a continuous variable) were used as the predictor variables. Intercept and slope parameters were estimated for the following models: (a) seed rain as a function of perches, (b) seed rain as a function of distance from the edge, (c) seed rain as a function of perches + distance from the edge, and (d) seed rain as a function of perches + distance from the edge + an interaction between perches and distance from the edge. These models were compared using AIC_c (Akaike's Information Corrected Criterion), and the relative importance of the different models was assessed based on AIC_c weights (Burnham and Anderson 1998; Johnson and Omland 2004). Statistical analysis was carried out using software R, version 2.5.0.



Fig. 2: Bamboo bird-perches (height: 7 m) erected at 0, 2, 4, 8, 16, 32, 64 m from the forest edge in Karvani, one of the abandoned clearings within Bhadra

RESULTS AND DISCUSSION

Effect of perches on seed arrival into clearings

Frugivorous birds observed frequenting the perches included Jungle Myna (*Acridotheres fuscus*), Common Myna (*A. tristis*), Grey-headed Starling (*Sturnia malabarica*) and Red-whiskered Bulbul (*Pycnonotus jocosus*). A total of 4,051 wind-dispersed seeds of 19 tree species were collected from 175 seed rain traps over five fortnightly collections. A total of 3,715 bird-dispersed seeds of 10 tree species were collected from 35 traps below perches in comparison with 390 bird-dispersed seeds of 7 tree species collected from 140 traps without perches over the same sampling period (refer Appendix).

The results of GLMs suggested that the perches had strongest effect on seed arrival (Table 1, Fig. 3). Distance from the forest-field edge had little-to-no effect on numbers of bird-dispersed seeds that arrived below perches. At any given distance from the forest-field edge, the mean density of bird-dispersed seeds collected under perches (seeds / 5 fortnights / sq. m) was about 38 times that of seeds collected from traps without perches (106.2 ± 95.0 cf. 2.8 ± 3.8), whereas

the mean density of wind- and bird-dispersed seeds that arrived below perches were about 25 times that of seeds collected from traps without perches (128.86 ± 155.85 cf. 5.09 ± 3.95). Perches not only enhanced the numbers of seeds arriving, but also augmented the mean number of species arriving into plots in clearings by a factor of 10.

The genus *Ficus* accounted for three of the ten species (and 95% of all seeds) collected below perches. *Ficus* species are of considerable value to forests in Asia as keystone resources due to their large crop size and asynchronous phenology (Borges 1993; Shanahan *et al.* 2001). About 40% of the *Ficus* seeds were from species such as *F. religiosa* and *F. mysorensis*, which are often cultivated in villages in India. Seed arrival was as low as 0.1 seed / sq. m during the study period in Hipla, a clearing with many remnant trees, indicating that perches are likely to be effective only in tree-less sites where birds are perch-limited, and not in sites with remnant trees.

Artificial perches have been introduced in other clearings adjoining forests (McClanahan and Wolfe 1993) with varying disturbance histories, such as grazing (Aide and Cavelier 1994; Holl 1998), and landslides (Shiels and Walker 2003). These studies have shown that seed arrival below

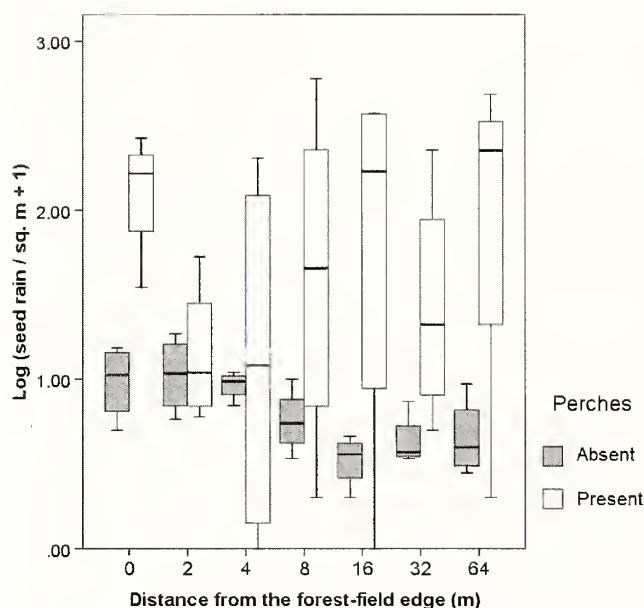


Fig. 3: Number of seeds collected in seed traps with and without bird-perches in five abandoned clearings within Bhadra at different distances from the forest edge. Data are number of seeds (bird- and wind-dispersed) collected between March 15 and May 31, 2006

perches is higher by a factor of 20 (Holl 1998; Shiels and Walker 2003) to 150 (McClanahan and Wolfe 1993) than in sites without perches. However, the effectiveness of perches in increasing seed rain was not reflected in seedling establishment; only one of these studies reported an increase in seedling establishment (McClanahan and Wolfe 1993). The

lack of improved seedling establishment in these studies was attributed to factors such as harsh micro-climatic conditions, seed predation, lack of nutrients in the soil and competition from existing vegetation in the clearings.

Factors such as perch height and design may also affect the number of bird visits: seed arrival has been reported to be higher below relatively taller trees, because they tend to attract more species of birds; taller perches, similarly, are likely to attract a greater number of bird species (Duncan and Chapman 1999; Toh *et al.* 1999). Holl (1998) found higher bird visit rates to, and seed dispersal below, branch perches compared with crossbar perches. The height of perches used in this study (about 7 m compared with average canopy height of 25-30 m in Bhadra) and the relatively thin lateral branches of bamboo perches may have deterred larger-bodied frugivores, such as barbets (*Megalaima* spp.) and green pigeons (*Treron* spp.) from visiting the perches.

Implications for restoration

Clearings within forests help maintain high densities of herbivores (and consequently, large carnivores), and thus management interventions frequently focus on maintaining such clearings (Schaller 1967; Karanth and Sunquist 1992). In the case of Bhadra, the abandoned agricultural fields may be maintained as clearings, akin to management practiced in other protected areas in India (e.g., Kanha and Nagarhole National Parks). However, findings from our study provide insights for restoration of slash-and-burn fallows, abandoned tea and coffee plantations, and other degraded lands where

Table 1: Effect of perches compared with that of distance from the forest edge, the combined effect of both, and interaction between the two, on number of bird-dispersed seeds that arrived below perches in five abandoned clearings within Bhadra TR

Model	Estimated parameters (SE)				Δ AIC _c	Model likelihood	AIC _c weights
Perch	Intercept		Perch		0	1	0.73
	0.713 (0.125)		0.847 (0.176)				
Perch + Distance	Intercept		Distance	Perch	1.99	0.37	0.27
	0.689 (0.146)		0.001 (0.004)	0.847 (0.178)			
Perch + Distance + Perch * Distance	Intercept		Distance	Perch	2.83	0.24	0
	0.762 (0.165)		-0.003 (0.006)	0.701 (0.233)			
Distance	Intercept		Distance		18.26	0	0
	1.112 (0.138)		0.001 (0.005)				

Perch * Distance denotes interaction between the two predictor variables

the management objective is clearly to restore the original vegetation.

We found that introducing perches is a simple and practical method to overcome the primary limitation of seed arrival into clearings and deforested land adjacent to forests, especially in relatively open sites where birds are perch-limited. Improved seed arrival does not necessarily translate into an increase in regeneration, however. In order to foster regeneration, augmenting seed arrival may need to go hand-in-hand with interventions to overcome other barriers to regeneration such as harsh micro-climatic conditions, competition with existing shrubs and grasses, and seed and seedling predation.

ACKNOWLEDGEMENTS

We thank the Rhino and Tiger Conservation Fund (US Fish and Wildlife Service), the Wildlife Conservation Society-India Programme, and the Centre for Wildlife Studies, Bengaluru, for funding and supporting this study, and Shankaranna, Prasad, Pradeep, and Subhash for assistance with data collection. The Karnataka Forest Department granted permission to work at Bhadra and provided logistical support. We also thank Drs. Ajith Kumar and Jagdish Krishnaswamy for their valuable comments.

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Appendix

List of tree species, seeds of which were collected from seeds traps in this study in Bhadra. Also given are the location where each species was encountered (i.e., whether in clearings, C, or in the adjoining forests, F), and the species' dispersal mode (A = animal-, B = bird- & W = wind-dispersed)

Tree species	Family	Clearing / Forest	Mode of dispersal
<i>Semecarpus anacardium</i>	Anacardiaceae	C	B / A
<i>Alstonia scholaris</i>	Apocynaceae	C / F	W
<i>Stereospermum personatum</i>	Bignoniaceae	C / F	W
<i>Terminalia alata</i>	Combretaceae	C / F	W
<i>Terminalia paniculata</i>	Combretaceae	C / F	W
<i>Albizia lebbbeck</i>	Fabaceae	C / F	W
<i>Albizia odoratissima</i>	Fabaceae	C / F	W
<i>Butea monosperma</i>	Fabaceae	C / F	W
<i>Cassia</i> spp.	Fabaceae	C / F	W
<i>Cassia tora</i>	Fabaceae	C / F	W
<i>Dalbergia latifolia</i>	Fabaceae	C / F	W
<i>Erythrina indica</i>	Fabaceae	C / F	W
<i>Erythrina</i> spp.	Fabaceae	C / F	W
<i>Pongamia pinnata</i>	Fabaceae	C / F	W
<i>Pterocarpus marsupium</i>	Fabaceae	F	W
<i>Lagerstroemia lanceolata</i>	Lythraceae	C / F	W
<i>Cipadessa baccifera</i>	Meliaceae	C	B / A
<i>Ficus racemosa</i>	Moraceae	C	B / A
<i>Ficus mysorensis</i>	Moraceae	C	B / A
<i>Ficus religiosa</i>	Moraceae	C	B / A
<i>Olea dioica</i>	Oleaceae	C	B / A
<i>Ziziphus xylopyrus</i>	Rhamnaceae	C	B / A
<i>Atalantia monophylla</i>	Rutaceae	C	B / A
<i>Santalum album</i>	Santalaceae	C	B / A
<i>Grewia tiliiaefolia</i>	Tiliaceae	C	B / A
<i>Tectona grandis</i>	Verbenaceae	C	W / A

Bird-dispersed seeds were collected below bamboo perches erected in the clearings

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